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(64) Method of virus-inactivating heat treatment of gamma-globulin.

(67) A gamma-globulin aqueous solution can be subjected to sterile heat-treatment without losing its activity when the treatment is conducted in the presence of at least one stabilizer which is a monosaccharide, disaccharide or sugar-alcohol added to the solution. The stabilizer serves to decrease the harmful polymer or anticomplement activity of the gamma-globulin before the treatment but to maintain the titer of a wide variety of antibodies to various viruses and bacteria, while the infectivity of viruses possibly contained is completely removed.

An additional stabilizer, which is a neutral amino, a neutral inorganic salt, an organic carboxylic acid salt or a surface active agent, assists the abovementioned stabilizer when used together with it.

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METHOD OF VIRUS-INACTIVATING HEAT TREATMENT  
OF  $\gamma$ -GLOBULIN

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1           This invention relates to a method of the heat  
treatment of an aqueous solution containing  $\gamma$ -globulin.  
More particularly, it relates to a method of a stable  
heat treatment of  $\gamma$ -globulin wherein a selected stabilizer  
5 is added to an aqueous solution of  $\gamma$ -globulin and no  
increase of the dimer or polymer of  $\gamma$ -globulin nor increase  
in anticomplement activity is observed after low tempera-  
ture pasteurization, i.e. a treatment conducted at 60°C  
for 10 hours.

10           Gamma globulin preparations containing, among  
immunoglobulins of a plasma protein component, particularly  
IgG as the principal ingredient have been widely used in  
the prevention and the treatment of various infectious  
diseases. However, they are not subjected to a heat-  
15 sterilization for the reason that they have a poor heat  
stability and that they contain a wide variety of antibodies  
to various viruses and bacteria, of which activity is liable  
to be lost.

          However, when  $\gamma$ -globulin is prepared from the  
20 fraction of plasma protein, the possibility of contamina-  
tion with viruses such as hepatitis viruses cannot be  
negated completely. Accordingly, it is important that  $\gamma$ -  
globulin preparations are subjected beforehand to a heat  
treatment at 60°C for 10 hours, which treatment has been  
25 widely recognized in the blood component preparation

1 technology as a method for inactivating contaminating  
viruses.

However, when the treatment is conducted in a  
conventional aqueous solution such as physiological saline  
5 solution, the solution becomes turbid in a short time,  
most of the activity being lost and the protein molecules  
being denatured.

After extensive studies, the present inventors  
have found that the thermal stability of  $\gamma$ -globulin against  
10 heat treatment is markedly improved when at last one  
member (hereinafter referred to generically as a principal  
stabilizer) selected from the group consisting of a mono-  
saccharide, a disaccharide, and a sugaralcohol is added  
to an aqueous solution containing  $\gamma$ -globulin prior to or at  
15 the time of the heat treatment of the solution for inactivating  
hepatitis viruses and that the thermal stability of  $\gamma$ -  
globulin is further enhanced when at least one member  
(hereinafter referred to generically as an auxiliary  
stabilizer) selected from the group consisting of a neutral  
20 amino acid, a neutral inorganic acid salt, a surface active  
agent, and an organic carboxylic acid salt is added to  
the solution in addition to the said principal stabilizer.  
This invention has been accomplished on the basis of above  
findings.

25 Further, the heat treatment according to the  
method of this invention make it possible to dissociate  
the dimer or polymer of  $\gamma$ -globulin contained in the aqueous  
 $\gamma$ -globulin solution into its monomer.

1           The aqueous solution containing  $\gamma$ -globulin to be  
heat-treated according to this invention may be an aqueous  
 $\gamma$ -globulin solution at any stage of purification ranging  
from an unpurified aqueous solution containing  $\gamma$ -globulin  
5 to a purified aqueous solution. However, an aqueous  
solution at a partially purified or purified stage is  
advantageously subjected to the heat treatment. The aqueous  
solution preferably contains 0.1 to 30% (w/v) of protein  
( $\gamma$ -globulin). The pH of the aqueous solution is preferably  
10 generally 4.5 to 10, and more preferably adjusted to pH 6 to  
8 with a suitable buffer solution.

As to the principal stabilizers added to the  
aqueous solution containing  $\gamma$ -globulin, preferred examples  
of a mono-saccharide include glucose, mannose, galactose,  
15 and fructose, those of a disaccharide include sucrose,  
maltose, and lactose, and those of a sugaralcohol include  
mannitol, sorbitol and xylitol, but they are not limited  
to these examples. The amount of the principal stabilizer  
to be added is preferably 10 to 100 g, more preferably 40 to  
20 100 g per 100 ml of aqueous  $\gamma$ -globulin solution.

Among the auxiliary stabilizers used in this  
invention, the neutral inorganic acid salts include, for  
example, the halide of alkali metals or alkaline earth  
metals such as sodium chloride, potassium chloride, and  
25 magnesium chloride. Their amount to be added is preferably  
0.1 to 10 g per 100 ml of aqueous  $\gamma$ -globulin solution.

Examples of the neutral amino acids (usually,  
monoaminomonocarboxylic acids) include glycine, alanine,

- 1 valine, leucine, and isoleucine. Their amount to be added is preferably 1 to 20 g per 100 ml of aqueous  $\gamma$ -globulin solution.

The organic carboxylic acid referred to in this invention is a compound comprising a hydrocarbon residue  
5 and a carboxyl substitute attached thereto. The hydrocarbon residue may be either saturated or unsaturated, and either chain-like (straight chain or branched chain) or cyclic. Examples of the hydrocarbon residue include an alkyl group and an aryl group (such as a phenyl group).  
10 The number of carboxyl groups in said organic carboxylic acid may be plural, but is preferably one or two. Further, said organic carboxylic acid may have a hydroxyl group. The organic acid has preferably about 3 to about 15 carbon atoms.

- 15 The kind of the salts of the organic carboxylic acids is not particularly restricted so long as it is physiologically acceptable. Preferred examples thereof include alkali metal salts such as sodium salts and potassium salts and alkaline earth metal salts such as  
20 calcium salts. Particularly preferable are sodium salts and potassium salts. The specific examples of the organic acid salts include particularly alkali metal salts (sodium or potassium salt) of propanoic, butanoic, pentanoic, caprylic, caproic, malonic, succinic, glutaric,  
25 adipic, citric and mandelic acid. The amount of the organic carboxylic acid salt to be added is 1 to 30 g per 100 ml of the aqueous  $\gamma$ -globulin solution.

Examples of the surface active agents usable in

- 1 this invention include nonionic surface active agents  
such as alkylphenyl-polyoxyethylene having a molecular  
weight of 500 to 1,000 [for example, Triton (a registered  
trade mark) and Nonidet (a registered trade mark)],  
5 anionic surface active agents such as bile acid salts,  
for example sodium taurocholate, cationic surface active  
agents such as benzalkonium chloride, and polyhydric  
alcohols having surface activity such as a high molecular  
weight copolymer of propylene oxide having a molecular  
10 weight of 2,000 to 12,000 [for example, Pluronic (a  
registered trade mark) F68]. Their amount to be added  
is preferably about 0.002 to about 0.05 g per 100 ml of  
the aqueous  $\gamma$ -globulin solution.

- The heat treatment should be conducted at a  
15 sufficient temperature and for a sufficient time for  
inactivating contaminating viruses only. For example,  
it is conducted at 50 to 70°C, preferably at about 60°C,  
for 5 to 20 hours, preferably for 10 hours.

- In order to examine the effect of the heat  
20 treatment according to this invention, the effect of  
heating in the presence of a principal stabilizer and that  
in the absence of the principal stabilizer were tested in  
the following manner on the infectivity of various viruses  
whose possible presence in  $\gamma$ -globulin preparations is  
25 apprehended. Thus, smallpox viruses, parotitis viruses,  
measles viruses, vesicular viruses, chikungunya viruses,  
polioviruses, coxsackie viruses, or echoviruses were added  
to a  $\gamma$ -globulin solution specimen, the resulting mixture

1 was heat-treated at 60°C for 10 hours, and the remaining  
infectivity of the viruses was determined with the lapse  
of time. The infectivity was found to have had vanished  
completely after 10 hours irrespective of the presence  
5 or the absence of the stabilizer. The result suggests  
that other viruses than those used above will lose their  
infectivity when heat-treated according to this invention.

After the above-mentioned heat treatment in the  
presence of the principal stabilizer according to this  
10 invention, the resulting product is examined for its  
appearance and properties and further subjected to the  
quantitative determination of dimer or polymer of  $\gamma$ -  
globulin, the determination of anticomplement activity,  
the determination of measles antibody titer, and the  
15 acute toxicity test. The results obtained reveal as dis-  
closed in the Example below, the decrease of the dimer  
or polymer and anticomplement activity of  $\gamma$ -globulin,  
but the remaining of the antibody titer, showing that  
it gives a  $\gamma$ -globulin preparation exhibiting an extremely  
20 high safety and a high effectiveness in medical treatment.

The product thus obtained is in a liquid state,  
and is dispensed, as it is when a highly purified  $\gamma$ -  
globulin has been used as the starting material and after  
treated according to a known method of purification fol-  
25 lowed, as required, by dialysis or sterile filtration  
when it has been derived from a crude product, so as to  
contain 50 to 10,000 mg of  $\gamma$ -globulin depending on package  
units. The method of its storage is not particularly

1 restricted so long as a high temperature is avoided.  
However, it is particularly preferably stored at a temper-  
ature not higher than 30°C or, as desired, may be made  
into a lyophilized preparation.

5 The  $\gamma$ -globulin thus treated is then administered  
as it is or after a preparation treatment known per se, for  
example after being diluted by or dissolved in or dialyzed  
against distilled water which may be for injection use.  
The usual dosage is 2,500 to 5,000 mg/kg body weight in  
10 terms of  $\gamma$ -globulin per one time for adults and 100 to  
150 mg/kg body weight in terms of  $\gamma$ -globulin per one time  
for infants.

The present invention is further explained by  
the following Examples, but it is not limited thereto.

15 In the Examples, in terms of the appearance,  
absorbance, O.D. 600 nm, was determined since turbidity  
becomes a problem.

The quantity of the dimer or the polymer was  
determined by means of high performance liquid chromato-  
20 graphy.

The anticomplement activity was determined  
according to the method of Kabatt and Meyer [Experimental  
Immunochemistry, 225 (1961)] and the method of Nishioka  
and Okada [Men'eki no Seikagaku (Biochemistry of immunity)  
25 103, (1971); published by Kyoritsu Shuppan Co.]. Namely,  
a specimen was added to 100 units of complement and the  
number of units remaining in the resulting mixture was  
determined. The anticomplement activity were expressed



1 in terms of the decreased units.

The measles antibody titer was determined by hemagglutination inhibition test and expressed in terms of international units (IU/150 mg).

5 Example 1

Experiments were made to confirm the stabilizing effect according to this invention. The experiments were conducted with samples prepared by adjusting a solution of a  $\gamma$ -globulin containing about 30% of polymer to a  
10 concentration of 5%. After the addition of various principal stabilizers (the amount added being indicated in the Table 1), the sample was heat-treated at 60°C for 10 hours and then examined for the turbidity (O.D. 600 nm) of the solution, the quantity of polymer and the anti-  
15 complement activity. The results obtained revealed that the stability of  $\gamma$ -globulin in heating was improved by the addition of stabilizer (Table 1).

Further, the decrease of amount of polymer, particularly dimer, was confirmed.

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Table 1

Stabilizer	Amount added *1	O.D. 600 nm	Polymer (%)		Anticomplement activity (unit)
			Dimer	Polymer	
Control (before heating)	-	0.024	33	2	54
None (for comparison)	-	Turbid	- *2	-	-
Glucose	50	0.010	15	2	38
Sucrose	50	0.012	13	2	36
Manitol	20	0.017	17	2	42

Note: \*1: Amount (g) per 100 ml of 5% (w/v)  $\gamma$ -globulin solution

\*2: So much as cannot be determined.

1 Example 2

- Glucose was added in various concentrations to a  $\gamma$ -globulin solution containing about 20% (w/v) of polymer and the concentration of  $\gamma$ -globulin in the resulting mixture was adjusted to 5% (w/v). The solution thus obtained was heat-treated at 60°C, and the value of O.D. 600 nm, the quantity of polymer, the anticomplement activity, and the measles antibody titer were determined with the lapse of time.
- 10 The system containing no glucose became turbid within one hour, showing the occurrence of denaturation. The systems containing added glucose showed increasing stability of  $\gamma$ -globulin with increasing amount of glucose added. The system to which 100 g of glucose had been
- 15 added did not become turbid and showed no decrease in the measles antibody titer even after heated at 60°C for 10 hours. Further, the content of dimer decreased down to only 10% and the anticomplement activity also decreased down to 19 units (Table 2).

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Table 2 Heat treatment at 60°C for 10 hours

Amount of glucose added (g)	O.D. 600 nm	Polymer (%)		Anticomplement activity (unit)	Measles antibody titer (10)
		Dimer	Polymer		
Control (before heating)	0.024	22	3	54	42
None	Turbid	- *1	-	-	-
5	Turbid	-	-	-	-
25	0.040	15	30	>50	<10.5
50	0.010	13	3	36	21
75	0.004	12	2	28	40
100	0.004	10	2	19	40

Note: \*1: So much as cannot be determined.

1 Example 3

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In addition to the principal stabilizer, glucose, one or two auxiliary stabilizers selected from a neutral amino acid (glycine), a neutral salt (sodium chloride),  
5 an organic carboxylic acid salt (sodium citrate), and a surface active agent (Pluronic<sup>®</sup> F68), were added to a  $\gamma$ -globulin solution and the stability of  $\gamma$ -globulin in the resulting solution in heat treatment at 60°C for 10 hrs was examined. The test was conducted with a  $\gamma$ -globulin  
10 solution same as in Example 1 but containing about 15% (w/v) of polymer.

Heat treatment at 60°C for 10 hours was conducted for each of the systems to which 75 g of glucose was added in common per 100 ml of  $\gamma$ -globulin solution and 5.8% (w/v)  
15 of sodium chloride, 5% (w/v) of glycine, 10% (w/v) of sodium citrate, 0.01% (w/v) of Pluronic<sup>®</sup> F68, or a combination of two auxiliary stabilizers, 5.8% (w/v) of sodium chloride and 0.01% (w/v) of Pluronic<sup>®</sup> F68, was added. The results obtained are shown in Table 3. The results  
20 reveal that the content of polymer and the anticomplement activity can be further decreased by the addition of the auxiliary stabilizers.

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Table 3

Auxiliary stabiliser (Referred to in Example 4)	Amount added (g)	O.D. 600 nm	Polymer (%)		Anti- complement activity (unit)	Measles antibody titer (IU)
			Dimer	Polymer		
Control (before heating)	-	0.004	15	2	44	42
None	-	0.004	8	1	28	40
Sodium chloride	5.8	0.004	5	1	18	42
Glycine	5	0.006	8	2	25	45
Sodium citrate	10	0.004	8	1	24	38
Pluronic® F68	0.01	0.004	6	1	13	40
Sodium chloride Pluronic® F68	5.8 0.01	0.004	6	1	12	41

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1 Example 4

Acute toxicity tests were conducted by way of a safety test.

Samples A, B, C, D, E and F which had been heat-  
5 treated at 60°C for 10 hours in Example 3 were dialyzed  
thoroughly against sterile physiological saline, and then  
administered respectively to mice in groups of five  
through the tail vein in a total amount of 0.5 ml and 1.0  
ml per one animal. No abnormality was found after 7 days  
10 of observation.

CLAIMS:-

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1. A method of a virus-inactivating heat treatment of an aqueous  $\gamma$ -globulin solution, comprising adding to the aqueous solution an amount sufficient for stabilizing  $\gamma$ -globulin therein of at least one stabilizer selected  
5 from the group consisting of a monosaccharide, a disaccharide and a sugaralcohol, and heating the aqueous solution at a temperature of 50° to 70°C for a period sufficient substantially to free the aqueous  $\gamma$ -globulin solution from infectivity of a virus.
- 10 2. The method of Claim 1, wherein the aqueous solution contains 0.1 to 30% (w/v) of  $\gamma$ -globulin in terms of protein.
3. The method of Claim 1, wherein the aqueous solution has a pH of 4.5 to 10.
- 15 4. The method of Claim 1 or 2, wherein the amount of the stabilizer is 10 to 100 g per 100 ml of the solution.
5. The method of Claim 4, wherein the amount of the stabilizer is 40 to 100 g per 100 ml of the solution.
6. The method of any preceding Claim, wherein in addition to  
20 the stabilizer, an amount effective for decreasing anti-complement activity as compared with the use of the stabilizer alone, of at least one auxiliary stabilizer selected from the group consisting of a neutral amino acid, a neutral inorganic acid salt, an organic carboxylic  
25 acid having 3 to 10 carbon atoms and a surface active agent is added to the aqueous solution.
7. The method of Claim 6, wherein the amount of the neutral amino acid is 1-20 g per 100 ml of the solution.



8. The method of Claim 6, wherein the amount of organic carboxylic acid is 1-30 g per 100 ml of the solution.

9. The method of Claim 6, wherein the amount of  
5 the inorganic acid salt is 0.1 to 10 g per 100 ml of the solution.

10. The method of Claim 6, wherein the amount of the surface active agent is 0.002 to 0.05 g per 100 ml of the solution.